



# Transportation Synthesis Report

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## Bridge Drainage Practices

Prepared for  
**Bureaus of Structures, Highway Development and Highway Construction**  
**Division of Transportation Infrastructure Development**

Prepared by  
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*Transportation Synthesis Reports (TSRs) are brief summaries of currently available information on topics of interest to WisDOT technical staff in highway development, construction and operations. Online and print sources include NCHRP and other TRB programs, AASHTO, the research and practices of other state DOTs, and related academic and industry research. Internet hyperlinks in TSRs are active at the time of publication, but changes on the host server can make them obsolete.*

### **REQUEST FOR REPORT**

The Bureaus of Highway Development, Structures and Construction asked the RD&T Program to research bridge deck drainage practices among north central states and New York. Specifically, information was sought on design preferences for bridge **Drainage Systems** and end drain systems, with a focus on use of surface drains, deck drains, end drains, and wing walls; practices for **Sealing** joints at pavement joints and approach joints; the use of expansion joints and materials at **Approach Joints and Wing Walls**; and specific bridge design **Resources** and **Contact** information with appropriate state transportation officials. The states of particular interest were Illinois, Iowa, Michigan, Minnesota, and New York.

### **SUMMARY**

A search of state transportation department Web sites and national transportation databases, and canvassing of bridge offices produced information on each of the states requested, and on Ohio, another north central state with a climate similar to Wisconsin's and a well-developed transportation concrete industry.

None of these states distinguish explicitly between bridge deck drainage and bridge end drainage systems; the latter inevitably is considered an element of the former in design manuals and specifications. Deck drainage systems included scuppers – openings at deck edges – in several states, though problems with drainage onto landscapes, highways, and waterways included safety and environmental concerns for states that avoided scupper use. Those that do use scuppers avoid use over waterways.

Iowa noted struggles with effective end drainage practices, and Michigan has abandoned the use of expansion joints as ineffective in accommodating drainage problems. Aside from Michigan, however, expansion joints are used and are sealed by states investigated here.

Wing walls prove a common design element in each investigated state, though Iowa favors wing walls running parallel to roadways rather than perpendicular.

Each state offers online access to its Bridge Design Manual, though some states defer some details of interest to design detail sheets and drawings, road manual, or other specification sources, many of which also can be read online. In most cases, items of specific interest to WisDOT's bureaus can be found in some detail.

### **ILLINOIS**

Drainage problems at slab ends forced a change in expansion joint policy in October 2003. The Drainage Manual and Bridge Manual were accessible online, as was a complete collection of memoranda on bridge design details.

**Drainage System.** Regulations recommend deck drainage via curbs and gutters, an effort to avoid deck drains. See Drainage Manual, §1-303.02. Floor drains consist of aluminum or fiberglass tubes, §1-303.022. Deck drainage

systems consist of either 6" floor drains or drainage scuppers. See Bridge Manual, §3.2.10, pp. 3-50 and 3-51. A new scupper policy provides design details; see All Bridge Designers Memorandum abd032, <http://www.dot.il.gov/bridges/abd032.pdf>.

**Sealing.** Sealed expansion joints may be preformed joint seals, strip seals, neoprene expansion joints, or finger plate joints with troughs, depending on bridge length. See Expansion regulations, sealant requirements, Bridge Manual, §3.4, pp. 3-97 through 3-100.

**Approach Joints and Wing Walls.** Concrete is cast directly against the wing walls and the approach slab drains. In Oct. 2003, a new policy for LRFD projects with expansion joints at concrete bridge slab ends attempted to correct incursion of water, soil and debris through failed joints by introducing channel sections. See All Bridge Designers Memorandum abd036, <http://www.dot.il.gov/bridges/abd036.pdf>.

**Resources.** The following can be viewed online.

- Drainage Manual, Bridge Manual, <http://www.dot.il.gov/bridges/brmanuals.html>.
- All Bridge Designers Memoranda, <http://www.dot.il.gov/bridges/bridges.html>.

**Contact.** Alex Siudyla, Bureau of Bridges and Structures, 217.785.2919, [siudylaas@dot.il.gov](mailto:siudylaas@dot.il.gov).

## **IOWA**

According to Gary Novey in the Bridge and Structures Office Iowa has been struggling with bridge end drainage issues. Erosion, cracking, and settling problems still afflict Iowa DOT at bridge ends and approach slabs. Bridge drainage systems remain preferred over draining off the bridge ends because of approach damage. End drains consist of rock or sod flumes for rural areas, storm sewer intakes for urban. For

**Drainage System.** Currently, Iowa DOT tries to bring the lip of the pavement up at the wing in an effort to channel water along curb. Also, the bridges office is considering increasing the number of deck drains, now limited by specifications, to reduce runoff to the bridge end drainages systems, and the office currently is reviewing management of water at the ends of bridges to reduce erosion and deterioration of approach pavement due to lost support.

**Sealing.** Iowa seals joints, including approach pavement, with hot poured sealers meeting ASTM D 6690, Type IV standards. Little benefit follows once movement begins, and erosion and cracking follow.

**Approach Joints and Wing Walls.** Includes 1-inch resilient filler between wing and pavement, as well as a 2- to 3-inch flexible foam expansion material or 1-inch resilient filler between wing end and approach slab as it wraps around wing. Wings designed parallel to road, not perpendicular. Currently approach slabs feature 3-inch gap in joint to bridge end, and IDOT is looking at new joint designs to narrow that gap. Filler and seals are used, but without success.

**Resources.** The following can be viewed online.

- For approach slab design issues, see English approach pavement standards, [http://www.dot.state.ia.us/design/stdplne\\_rk.htm](http://www.dot.state.ia.us/design/stdplne_rk.htm), or Metric, [http://www.dot.state.ia.us/design/stdplnm\\_rk.htm](http://www.dot.state.ia.us/design/stdplnm_rk.htm).
- Various bridge standards in English and Metric versions, <http://www.dot.state.ia.us/bridge/standard.html>.
- Construction handbooks, <http://www.dot.state.ia.us/construction/structures.htm>.
- Bridge Design Manual and Commentary, <http://www.dot.state.ia.us/bridge/polframe.html>.
- English Bridge Standards, [http://www.msp.dot.state.ia.us/bridge\\_design/ebrg\\_frame.htm](http://www.msp.dot.state.ia.us/bridge_design/ebrg_frame.htm).
- English Culvert Standards, [http://www.msp.dot.state.ia.us/bridge\\_design/ecul\\_frame.htm](http://www.msp.dot.state.ia.us/bridge_design/ecul_frame.htm).
- Bridge and Structures Office, <http://www.dot.state.ia.us/bridge/index.htm>.

**Contact.** Gary Novey, Assistant Bridge Engineer, 515.239.1564 or [Gary.Novey@dot.iowa.gov](mailto:Gary.Novey@dot.iowa.gov).

## **MICHIGAN**

Michigan DOT has discontinued use of expansion joints, which proved ineffective. Instead, the agency has been working with sleeper slabs for the last six years, and felt seals for approach slabs.

**Drainage System.** Deck end drainage relies on curb and gutters, which channel water to downspouts directed off the slope.

**Sealing.** Pavement seals are used with the new, E-3 joint design. On the sleeper-slab pavement joint and seal, see Standard Plans, R-39G, at <http://www.mdot.state.mi.us/design/englishstandardplans/files/R039G.pdf>.

**Approach Joints and Wing Walls.** The new sleeper slabs extend the bridge deck end 20 feet past the bridge end design reference line. An E-3 joint, with felt and sealant, may be used, or a saw cut sealed with hot mix asphalt. Wings rarely used anymore, though radial bends at the end of the bridge may be used. For specific sleeper and approach slab details, see the Bridge Design Guide

- §6.20.04, <http://www.mdot.state.mi.us/design/englishbridgeguides/62004.pdf0>;
- §6.20.04A, <http://www.mdot.state.mi.us/design/englishbridgeguides/62004A.pdf>;
- §6.20.04B, <http://www.mdot.state.mi.us/design/englishbridgeguides/62004B.pdf>; and
- §6.20.04C, <http://www.mdot.state.mi.us/design/englishbridgeguides/62004C.pdf>.

On bridge approach curb and gutter design, see Standard Plans, R-32 at <http://www.mdot.state.mi.us/design/englishstandardplans/files/R032E.pdf>.

**References.** The following can be viewed online.

- For specifications, see Standard Plans at <http://www.mdot.state.mi.us/design/englishstandardplans/index.htm>.
- Bridge Design Manual, <http://www.mdot.state.mi.us/design/englishbridgemanual/>.
- Drainage Manual, <http://www.mdot.state.mi.us/stormwater/drainagemanual.cfm>.
- For processes, details, and drawings, see Bridge Design Guide at <http://www.mdot.state.mi.us/design/englishbridgeguides/>.

**Contact.** Vladimir Zokvic, Bridge Standards Specialist, 517.373.0740 or [zokvicv@michigan.gov](mailto:zokvicv@michigan.gov).

## **MINNESOTA**

MnDOT bridge office personnel did not provide specific information, but design manuals and standard plan details were available online and yielded the following information.

**Drainage System.** Drainage must avoid entering state waters; bridges less than 500 feet over state waters must be designed to shed water longitudinally without deck drains, and longer required closed systems – §9.1.1 LRFD Bridge Design Manual, §9-2.01.02(3). Grated drains and scuppers are used in various designs – see Bridge Details Manual I, B701, B702, B705, B706, and B710. For abutments and slab over abutments, see Bridge Details Manual I, B910 and B911.

**Sealing.** Strip seal expansion joints at abutments; expansion joint options for structure include modular expansion joints, LRFD Bridge Design Manual §14.2. For specifications on sealing practices, see Specification Book, 2000 Edition, §§3719-3725, <http://www.dot.state.mn.us/tecsup/spec/2000/sp3501.pdf>.

**Approach Joints and Wing Walls.** Design detail on this item was not accessible online and not provided by bridge office personnel.

**Resources.** The following can be viewed online.

- LRFD Bridge Design Manual, <http://www.dot.state.mn.us/bridge/Manuals/LRFD/index.html>.
- Road Design Manual, Ch. 9, Bridges and Other Structures, <http://www.dot.state.mn.us/tecsup/rdm/english/9e.pdf>.
- Standard Plan Sheets, <http://www.dot.state.mn.us/tecsup/splan/english.html#5-297.400>.
- Bridge Details Manual I, <http://www.dot.state.mn.us/bridge/Manuals/BridgeDetailsManualPart-I/index.html>.

**Contact.** Duane Green, Bridge Design Unit, 651.747.2183 or [duane.green@dot.state.mn.us](mailto:duane.green@dot.state.mn.us). MnDOT Bridge Office personnel, listed according to functional unit, can be identified and contacted via <http://www.dot.state.mn.us/bridge/People/>.

## **NEW YORK**

New York prefers scuppers to closed drainage systems, according to officials. However, various drainage system options are detailed in the Bridge Manual and Bridge Detail Sheets.

**Drainage System.** Drainage system encompasses deck end, and includes drains three meters from the approach slab or wing wall end. Drainage inlets not often used adjacent to bridge deck. Scuppers are used when water quality will not be compromised, and stone curbs run water off the bridge to stone gutters. Bridge Manual, §5.4 at <http://www.dot.state.ny.us/structures/manuals/brman/sect05.pdf>. For scupper details, see BD Sheets BD-MS1 and BD-MS2 at <http://www.dot.state.ny.us/caddinfo/structures/files/bdms1.pdf> and <http://www.dot.state.ny.us/caddinfo/structures/files/bdms2.pdf>.

**Sealing.** NYDOT uses either modular joints with a seal, armorless joints with elastomeric concrete headers and pourable seals or foam, jointless details or integral abutment details. See Bridge Manual, §5.5 <http://www.dot.state.ny.us/structures/manuals/brman/sect05.pdf>. See BD-AD Sheets, as well as IA, JA, JM, and JT, all at <http://www.dot.state.ny.us/caddinfo/structures/bd.html>.

**Approach Joints and Wing Walls.** Jointed details include sealants as above. When jointless details used, joints may yet be included at the approach slab to concrete highway pavement connection. For jointless details, see Bridge Manual §5.2. For approach drainage drawings, BD-AD Sheets, <http://www.dot.state.ny.us/caddinfo/structures/bd.html#AD>. For approach slab design details, BD-AS Sheets at <http://www.dot.state.ny.us/caddinfo/structures/bd.html#SA>.

**Resources.** The following can be viewed online.

- For bridge deck design matters, see Bridge Manual Ch. 5, <http://www.dot.state.ny.us/structures/manuals/brman/sect05.pdf>.
- For all bridge detail technical drawings, see Bridge Detail Sheets at <http://www.dot.state.ny.us/caddinfo/structures/bd.html>.

**Contact.** James Flynn, Standards & Policies Unit, 518.485.1148 or [jhflynn@dot.state.ny.us](mailto:jhflynn@dot.state.ny.us).

## **OHIO**

ODOT avoids the use of deck drains, and though it uses sodded flumes at expansion joints, finds them poor performers.

**Drainage System.** Deck drains generally are avoided. In its section on bridge deck drainage, the Bridge Design Manual calls for limiting or eliminating scupper use; see Bridge Deck Drainage, §209.3. End drains entail sealed joints with sodded flumes down embankments, or catch basins in situations of high flow rates.

**Sealing.** Expansion joints are required every 90 feet with certain exceptions, and are strip sealed; see Expansion and Contraction Joints, §303.2.5. The Bridge Design Manual varies expansion joint options with bridge type, including polymer modified seals, strip seals, modular expansion devices, and more; see Ch. 306, Expansion Devices.

**Approach Joints and Wing Walls.** ODOT calls for Type A pressure relief joints at approach pavement on integral bridges. For pressure relief joint details, see Standard Construction Drawings Pavement Design Features BP-Series BP 2-3 at <http://www.dot.state.oh.us/pavement/pubs/SCD.htm>.

**Resources.** The following can be viewed online.

- Bridge Design Manual, <http://www.dot.state.oh.us/se/BDM/BDM2004/bdm2004.htm>.
- For Approach Slabs, generally, see Bridge Design Manual, §209.5.
- Office of Structural Engineering, <http://www.dot.state.oh.us/se/>.

**Contact.** Bill Krouse, Office of Structural Engineering, 614.466.2398 or [Bill.Krouse@dot.state.oh.us](mailto:Bill.Krouse@dot.state.oh.us).

## **NATIONAL**

The last NCHRP synthesis report on bridge drainage was 25 years ago. Since then, bridge deck drainage has not been a prominent research interest. Recent work on bridge deck joints turned up little information of interest, and a search of national databases provided few clues as to what other states or countries may be of interest for further research.

**NCHRP Synthesis Report 319, Bridge Deck Joint Performance, 2003.** Focuses on joint construction practices for concrete decks, and includes a survey of state DOTs, certain agencies around the world, and Canadian provinces, of which 49 responded. Responses detailed in Part 3, Question 8, show that most of the 35 respondent state DOTs seal deck ends, and most turn the seal up at deck ends, sometimes shaping the seal up the curb and/or parapet. See p. 19. [http://trb.org/publications/nchrp/nchrp\\_syn\\_319.pdf](http://trb.org/publications/nchrp/nchrp_syn_319.pdf).

**Japan.** In this 2002 Transcan, a scan tour of Asian bridges found the Japanese successfully employing perforated steel curbs on the concrete deck of the Akashi-Kaikyo Bridge for draining water via pipes to abutments. [http://gulliver.trb.org/publications/nchrp/transcan\\_2.pdf](http://gulliver.trb.org/publications/nchrp/transcan_2.pdf).

**Colorado.** A 1999 policy on deck drainage describes a complete drainage system as entailing a deck and an end drainage plan; calls for gray iron drain grates rather than galvanized steel – [http://www.dot.state.co.us/Bridge/DesignManual/dm\\_s16.pdf](http://www.dot.state.co.us/Bridge/DesignManual/dm_s16.pdf).

**New Jersey.** Design manual requires catch basins at bridge ends – <http://www.state.nj.us/transportation/eng/documents/BDMM/pdf/bmsec22.pdf>.